AIR QUALITY AND AIR QUALITY RELATED VALUES MONITORING CONSIDERATIONS FOR THE ROCKY MOUNTAIN NETWORK

March 2005

Introduction

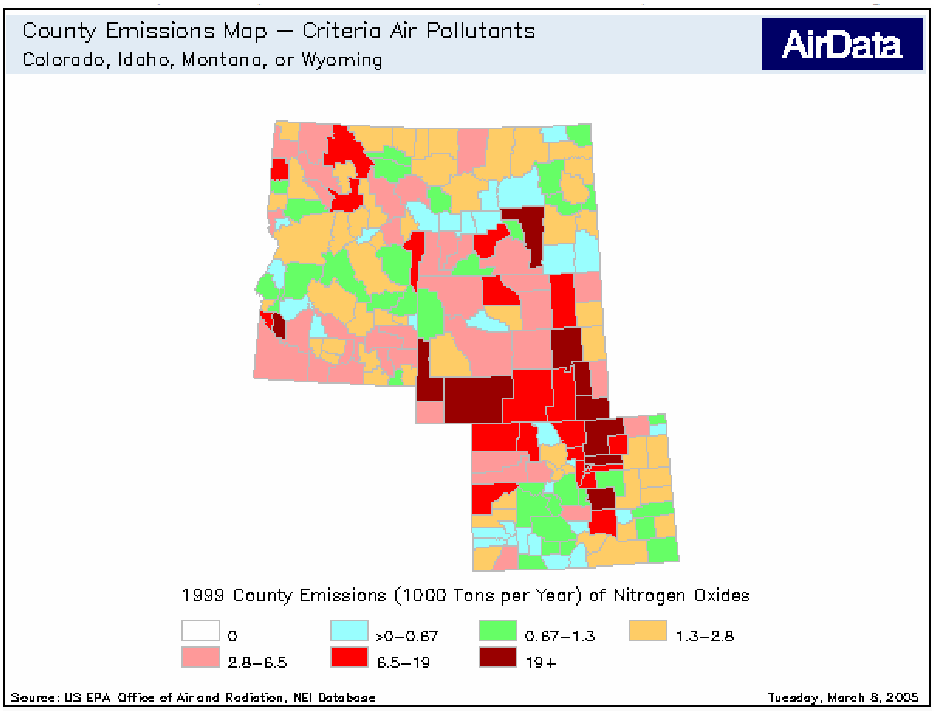
The Rocky Mountain Network (ROMN) of the National Park Service (NPS) Inventory and Monitoring Program includes Florissant Fossil Beds National Monument (NM), Glacier National Park (NP), Great Sand Dunes NP, Grant-Kohrs Ranch National Historic Site (NHS), Little Bighorn NM, and Rocky Mountain NP. Glacier NP, Great Sand Dunes NP, and Rocky Mountain NP are Class I air quality areas, receiving the highest protection under the Clean Air Act. The other park units are Class II air quality areas and also receive protection under the Act. Air quality and related information for the Class I parks is available from the Air Resources Information System (ARIS) at http://www2.nature.nps.gov/air/Permits/ARIS/index.htm. Air quality and related information for the network is at http://www2.nature.nps.gov/air/Permits/ARIS/networks/index.htm.

Although most of the park units in the network are some distance from cities and pollution sources, many experience poor air quality from pollutants such as ozone, nitrogen oxides, sulfur dioxide, volatile organic compounds, particulate matter, and toxics. These air pollutants affect, or have the potential to affect, air quality and natural resources in ROMN, including vegetation, wildlife, soils, water quality, and visibility. High levels of ozone in the area, for example, may affect vegetation, as well as the health of park visitors and staff. Nitrogen compounds from the atmosphere affect water quality and biota, soil nutrient cycling and plant species composition. Pollutant particles in the air reduce visibility and affect how far and how well we can see. Atmospheric deposition of toxic organic compounds and metals, including mercury, may have a wide range of effects on fish and wildlife. The following sections describe air pollutant emissions, air quality monitoring, and air pollutant concerns for resources in the network.

Air Pollutant Emissions

Air quality in the network is affected primarily by air pollution sources in Colorado, Wyoming, Montana, and Idaho, although more distant sources can also affect the area's air quality. Air pollutant emissions come from a variety of sources, including mobile sources (e.g., cars, trucks, off-road vehicles), stationary sources (e.g., power plants and industry), and area sources (e.g., agriculture, fires, and road dust).

Figure 1 shows distribution maps for emissions of nitrogen oxides and sulfur dioxide in Colorado, Wyoming, Montana, and Idaho. Major sources of nitrogen oxides include cars and other mobile sources, compressors, power plants and industry. The major sources of sulfur dioxide are coal-burning power plants, industry, and diesel engines. Agricultural ammonia emissions, which contribute significantly to total nitrogen deposited from the atmosphere into ecosystems, are not included in these maps. Additional information on pollutant sources can be found at http://www.epa.gov/air/data/index.html.



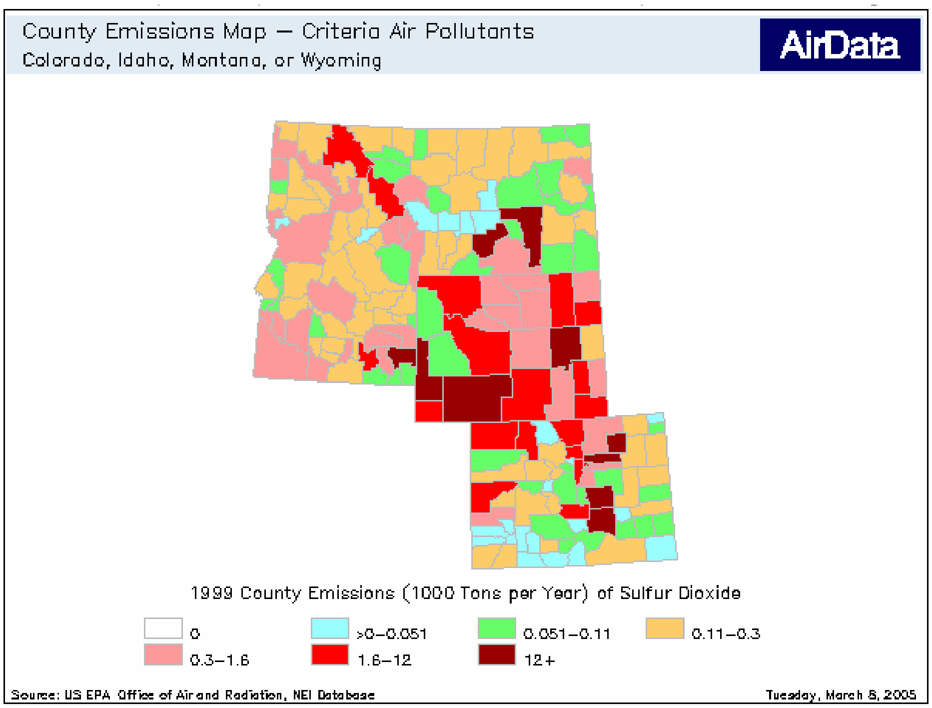


Figure 1. Air pollutant emissions of nitrogen oxides and sulfur dioxide, by county, in Colorado, Wyoming, Montana, and Idaho. Emissions are given in thousands of tons per year (from EPA AirData at http://www.epa.gov/air/data/index.html).

Air Quality Monitoring and Effects

Figure 2 shows current air quality monitoring in and near ROMN. Types of monitoring include ozone monitoring by the NPS Gaseous Pollutant Monitoring Network (GPMN) and ozone monitoring by States (Ozone); wet deposition (rain, snow) monitoring of atmospheric pollutants by the National Atmospheric Deposition Program/National Trends Network (NADP/NTN); wet deposition monitoring of mercury by the Mercury Deposition Network (MDN); dry deposition (dryfall) monitoring of atmospheric pollutants by the Clean Air Status and Trends Network (CASTNet); and visibility monitoring by the Interagency Monitoring of Protected Visual Environments (IMPROVE) Program. The history of monitoring (including current and past monitoring) at each park unit can be found at http://www2.nature.nps.gov/air/Monitoring/MonHist/index.cfm.

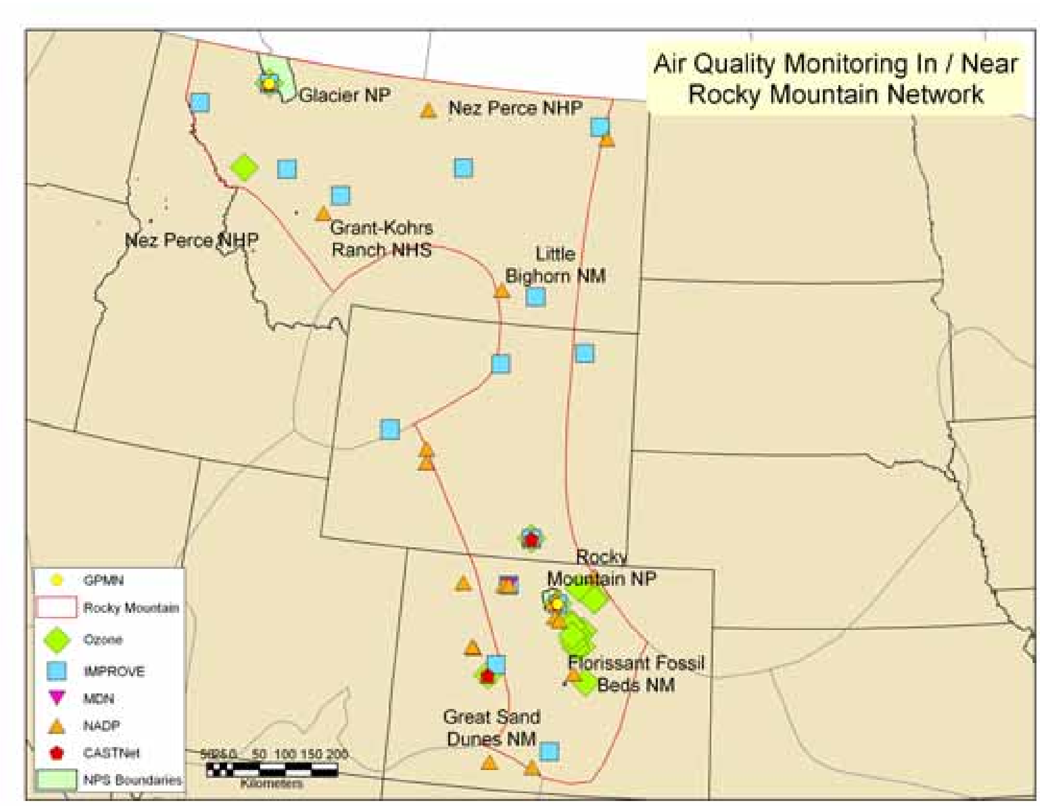


Figure 2. Air quality monitoring in ROMN (GPMN=NPS Gaseous Pollutant Monitoring Network for ozone; NADP= National Atmospheric Deposition Program; MDN=Mercury Deposition Network; CASTNet= Clean Air Status and Trends Network; IMPROVE=Interagency Monitoring of Protected Visual Environments; Ozone=ozone monitoring by States.

Table 1 lists air quality monitoring sites in or near ROMN units. Glacier NP, Rocky Mountain NP, and Little Bighorn NM have on-site monitoring of wet deposition; Glacier NP and Rocky Mountain NP have dry deposition monitoring; Glacier NP has mercury deposition monitoring; Glacier NP, Great Sand Dunes NP, and Rocky Mountain NP have visibility monitoring; Glacier NP and Rocky Mountain NP have continuous ozone monitoring.

Table 1. Current air quality monitoring sites in and near NPS units in ROMN. Air quality data for on-site monitors can be obtained from the monitoring network websites listed below. Air quality estimates for park units without on-site monitoring are available from NPS Air Atlas at http://www2.nature.nps.gov/air/Maps/AirAtlas/index.htm. The following table also identifies nearby monitors for inventory purposes. Data from distant monitors are unlikely to be representative of conditions in a park unit; Air Atlas estimates should be used in these cases.

PARK	NADP/NTN		MDN		CASTNet		IMPROVE		OZONE	
	LOCATION	SITE #	LOCATION	SITE#	LOCATION	SITE #	LOCATION	SITE #	LOCATION	SITE #
FLFO	Manitou 30 km E	CO21							Manitou Springs 30 km E	080410016
GLAC	On-site	MT05	On-site	MT05	On-site	GLR468	On-site	GLAC1	On-site	300298001
GRKO	Clancy 40 km E	MT07								
GRSA	Alamosa 40 km SW	CO00					On-site	GRSA1		
LIBI	On-site	MT00								
ROMO	On-site Loch Vale On-site Beaver Meadows	CO98 CO19			On-site	ROM406	On-site	ROMO1	On-site	080690007

NADP/NTN = National Atmospheric Deposition Program at http://nadp.sws.uiuc.edu/
MDN = Mercury Deposition Network at http://nadp.sws.uiuc.edu/mdn/
CASTNet = Clean Air Status and Trends Network at http://www.epa.gov/castnet/
IMPROVE = Interagency Monitoring of Protected Visual Environments at http://vista.cira.colostate.edu/views/
Ozone = EPA AirData at http://www.epa.gov/air/data/index.html or NPS AirWeb at http://www2.nature.nps.gov/air/data/index.htm

FLFO = Florissant Fossil Beds NM
GLAC = Glacier NP
GRKO = Grant-Kohrs Ranch NHS
GRSA = Great Sand Dunes NP
LIBI = Little Bighorn NM
ROMO = Rocky Mountain NP

Air Quality Estimates: Air Atlas

For park units without on-site monitoring, estimates of many air quality parameters can be found in Air Atlas at http://www2.nature.nps.gov/air/Maps/AirAtlas/index.htm. Air Atlas is a mini-GIS tool that provides national maps and an associated look-up table with baseline values of air quality parameters for all Inventory and Monitoring (I&M) parks in the U.S. The values are based on averaged 1995-1999 data. Air Atlas was produced by the NPS Air Resources Division in association with the University of Denver. Air Atlas serves as the air inventory for parks.

The estimated air quality values provided in Air Atlas are based on the center of the polygon defining the park or multiple units of the park. Data from all available monitors operated by NPS, States, and EPA, and other programs are used for the interpolation of the air quality values.

Air Atlas contains a comprehensive set of air quality parameters for all I&M parks. Table 2 summarizes a select group of air quality parameters for ROMN.

Table 2. Estimates of selected air quality parameters for units of ROMN (from Air Atlas at http://www2.nature.nps.gov/air/Maps/AirAtlas/index.htm)

ROCKY MOUNTAIN NETWORK		Ozone ----------					NADP (kg/ha/yr) ===		Visibility - IMPROVE	
	CLASS	2ndHi1hr	4thHi8hr	#8hr>85	#1hr>100	Sum06_3Mo	Total S	Total N	b_{ext}Clear	b_{ext}Hazy
Florissant Fossil Beds NM	2	97.2	71.3	1.6	2.2	6.9	1.50	2.45	6	24
Glacier NP	1	72.4	57.7	0.3	0.4	1.0	0.35	0.72	11	54
Grant-Kohrs Ranch NHS	2	90.5	68.9	1.4	3.2	5.8	0.45	0.7	7	37
Great Sand Dunes NP	1	94.3	70.7	1.4	1.8	9.7	1.16	1.94	7	24
Little Bighorn NM	2	84.9	67.1	0.5	1.1	9.1	0.73	1.33	6	28
Rocky Mountain NP	1	99.1	73.1	1.7	2.2	17.0	1.81	3.01	5	25

Class: refers to an area's designation under the Clean Air Act
Ozone information represents 5-yr average of annual values from 1995-1999
  2nd High 1 hr concentration (ppb): indicates peak values for ozone; old standard of 0.12 ppm (120 ppb) was based on 2nd hi,1-hr average
  4th high 8 hr concentration (ppb): new ozone standard of 0.08 ppm (80 ppb) is based on 4th hi, 8-hr average
  #8 hours>85 ppb: indicates how often the area would be in violation of the new 8-hr standard of 0.08 ppb
  # hours> 100 ppb: high peaks in ozone concentration, as well as cumulative dose, contribute to vegetation injury
  SUM06_3mon (ppm-hrs) - sum of hourly ozone conc.≥0.06 ppm (60 ppb) over 3 months (~ growing season), i.e., cumulative ozone dose
NADP information represents 6-yr average of annual values from 1995-2000
  NADP deposition (kg/ha/yr): estimate of pollutants deposited to ecosystem by precipitation (NADP-National Atmospheric Deposition Program)
  NADP Total S - sulfur from sulfate deposited by precipitation
  NADP Total N - inorganic nitrogen (ammonium plus nitrate) deposited by precipitation
Visibility IMPROVE information represents 5-yr average of annual values from 1995-1999
  bextClear - measure of light scattering and absorption, i.e., extinction, by particles in the air on an average clear day
  bextHazy - measure of light scattering and absorption, i.e., extinction, by particles in the air on an average hazy day

Wet Deposition Monitoring of Atmospheric Pollutants

Glacier NP, Rocky Mountain NP, and Little Bighorn NM have on-site monitoring of wet deposition as part of NADP/NTN. The sites at Glacier NP and Rocky Mountain NP are supported by the NPS; the site at Little Bighorn NM is supported by the U.S. Geological Survey. Monitoring began at Glacier NP in 1980; at Rocky Mountain NP in 1980 (Beaver Meadows) and 1983 (Loch Vale); at Little Bighorn NM in 1984. Great Sand Dunes NP, Grant-Kohrs Ranch NHS, and Florissant Fossil Beds NM each have an NADP sampler about 40 km distant. NADP/NTN collects data on both pollutant deposition (in kilograms per hectare per year – kg per ha per yr) and pollutant concentration (in microequivalents per liter – µeq per L). Deposition varies with the amount of annual precipitation, and is useful because it gives an indication of the total annual pollutant loading at the site. Concentration is independent of precipitation amount; therefore, it provides a better indication of whether ambient pollutant levels are increasing or decreasing over the years, despite rainfall fluctuations. In general, wet deposition and concentration of sulfate, nitrate, and ammonium are low in the western U.S. relative to the Midwest and East. Pollutant deposition in the ROMN is consistent with this pattern. A trend analysis of 1994-2003 data indicates that sulfate concentrations are decreasing at many sites in the West; however, nitrate and ammonium concentrations are increasing at those sites (Appendix A, figures A.1 - A.3).

Dry Deposition Monitoring of Atmospheric Pollutants

Glacier NP and Rocky Mountain NP have on-site monitoring of dry deposition (since 1995 and 1994, respectively) as part of CASTNet. These sites are supported by the NPS and EPA. The other units in ROMN are distant from any CASTNet monitors; estimates of dry pollutant concentrations for these park units can be obtained from AirAtlas.

There is insufficient long-term dry deposition data available to do a trend analysis similar to that described for wet deposition. In general, trends in dry deposition are likely to follow trends in wet deposition.

Total Atmospheric Deposition

When assessing ecosystem impacts from atmospheric deposition it is desirable to have estimates of total deposition, that is, wet plus dry deposition plus cloud/fog deposition. There is no national program for monitoring cloud and fog deposition, and therefore total deposition is usually estimated from NADP and CASTNet data, a method that may underestimate total deposition in areas of frequent cloud and fog.

NADP and CASTNet data indicate that deposition of both nitrogen and sulfur are elevated above natural levels of deposition. Estimates of natural deposition for either sulfur or nitrogen in the West are approximately 0.2 kg per ha per yr. Total nitrogen deposition at Rocky Mountain NP, for example, averages around 3.9 kg per ha per yr (NADP 1999-2003 and CASTNet 1999-2003) (http://www.cdphe.state.co.us/ap/rmnp/noxtech.pdf).

Atmospheric Deposition Effects to Ecosystems

Atmospheric deposition of nitrogen and sulfur compounds can affect water quality, soils, and vegetation. Both nitrogen and sulfur emissions can form acidic compounds (e.g., nitric or sulfuric acid); when deposited into ecosystems with low buffering capacity, acidification of waters or soils can occur. Certain high elevation lakes, streams, and soils in Glacier NP, Great Sand Dunes NP, and Rocky Mountain NP may not have sufficient buffering capacity to sustain long-term deposition. A waterbody with an acid neutralizing capacity of less than 100 µeq per L is considered at risk from episodic acidification (particularly during snowmelt) or chronic acidification. Some of the lakes and streams in ROMN have naturally low buffering capacity (ANC<50 µeq per L) and therefore are very sensitive to episodic and chronic acidification. Assessments are underway to evaluate sensitive lakes and streams in Rocky Mountain NP, Glacier NP, and Great Sand Dunes NP. Ecosystem modeling is being conducted to estimate the amount of deposition that would cause acidification in Rocky Mountain NP streams and lakes (http://www2.nature.nps.gov/air/studies/NSDeposition.htm).

Deposition of nitrogen compounds can also have a fertilization effect on waters and soils. In some areas of the country, elevated nitrogen deposition has been shown to alter soil nutrient cycling and vegetation species composition. Ecosystems in Rocky Mountain NP are being changed by nitrogen deposition. Long-term studies at the Loch Vale watershed and other locations in the park have found changes due to nitrogen deposition including shifts in diatom species and nitrate levels in high elevation lakes, increased soil nitrogen, and lower C:N in soils and vegetation (http://www.nrel.colostate.edu/projects/lvws/pages/homepage.htm). Ecosystem studies at the Niwot Ridge Long-Term Ecological Research site adjacent to Rocky Mountain NP show that increased nitrogen causes changes in species composition of alpine tundra vegetation, changes that may also be occurring in the park. Ecosystems in the other ROMN units may also be sensitive to change from nitrogen deposition. Over time, excess nitrogen deposition may cause native plants that have adapted to nitrogen-poor conditions to be out-competed and replaced by nitrogen-loving nonnative grasses and other exotic species. In addition to changes in species composition, there may be increases in productivity, resulting in increased biomass (i.e., fuel loading) and fire frequency.

Ground-level Ozone Monitoring
Glacier NP and Rocky Mountain NP have continuous ozone monitoring within the parks. Ozone monitoring was initiated in 1987 in Rocky Mountain NP and 1992 in Glacier NP. These sites are supported by NPS. They supply hourly ozone values that can be used to identify peak concentrations and compliance with the EPA standard for ozone, and to calculate ozone exposure metrics used to evaluate risk of injury to vegetation. Estimates of ozone peak concentrations and exposure metrics for the other ROMN units can be obtained from AirAtlas. In addition to NPS monitors, there are a number of State-operated ozone monitors in the region.

Data from these monitors has been used by the States and EPA to determine compliance with the EPA ozone standard (based on an 8-hr averaging period). Part or all of 474 counties nationwide are designated as nonattainment for either failing to meet the 8-hour ozone standard or for causing a downwind county to fail (Figure 4). Over 100 park units are in these ozone nonattainment areas, including portions of Rocky Mountain NP. These areas experience ozone concentrations that are at times harmful to visitor and staff health. The States are required to develop plans to bring these areas into compliance with the standard. A trends analysis for 1994-2003 indicates that ozone is increasing in the ROMN area (Appendix A, figure A.4).

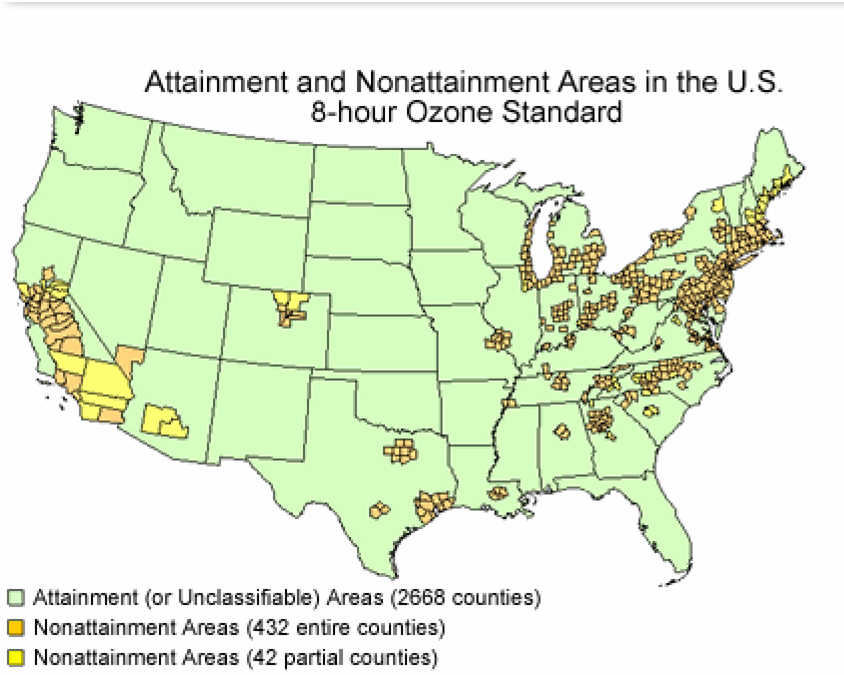


Figure 5. Attainment and nonattainment areas in the U.S. for the 8-hr ozone standard (from http://www.epa.gov/oar/oaqps/glo/designations/index.htm).

Ground-level ozone is produced by the reaction of nitrogen oxides (NO_x) and volatile organic compounds (VOCs) in the presence of sunlight. Ozone is a strong oxidant. Upper-atmospheric ozone (i.e., stratospheric ozone) acts as a protective shield against ultraviolet radiation; ground-level ozone (i.e., tropospheric ozone) is harmful to human health and vegetation. Although ground-level ozone is principally an urban problem, it and its precursor emissions can travel long distances, resulting in elevated ozone levels in national park units. Power plants, automobiles, and factories are the main anthropogenic emitters of nitrogen oxides. Vehicles and industries also emit VOCs. Natural biogenic VOC emissions are also significant in some geographic areas.

Ozone affects human health, causing acute respiratory problems, aggravation of asthma, temporary decreases in lung capacity in some adults, inflammation of lung tissue, and impairment of the body's immune system. Chamber studies have shown ozone effects to birds and other wildlife. However, these effects to birds and wildlife have not been demonstrated in the wild. Effects to vegetation have been widely documented and ozone is one of the most widespread pollutants affecting vegetation in the U.S. Ozone enters plants through leaf stomata and oxidizes plant tissue, causing changes in biochemical and physiological processes. Both visible foliar injury (e.g., stipple and chlorosis) and growth effects (e.g., premature leaf loss, reduced photosynthesis, and reduced leaf, root, and total dry weights) can occur in sensitive plant species. Long-term exposures can result in shifts in species composition, with ozone tolerant species replacing intolerant species.

Research shows that some plants are more sensitive to ozone than humans, and effects to plants occur well below the EPA standard. Ozone causes considerable damage to vegetation throughout the world, including agricultural crops and native plants in natural ecosystems. Ozone effects on natural vegetation have been documented throughout the U.S., particularly in many areas of the East and in California. A relatively small number of national parks have been surveyed for ozone injury; injury has been documented in Great Smoky Mountains, Shenandoah, Lassen Volcanic, Sequoia/Kings Canyon, and Yosemite National Parks.

Scientists use various metrics to describe ozone exposure to plants, in addition to the 1-hour or 8-hour average concentrations reported by EPA. These metrics, the Sum06 and the W126, are believed to be biologically relevant, as they take into account both peak ozone concentrations and cumulative exposure to ozone. Hourly concentrations from a continuous or portable continuous ozone analyzer are needed to calculate either metric.

Sum06 -- The running 90-day maximum sum of the 0800-2000 hourly ozone concentrations of ozone equal to or greater than 0.06 ppm. The Sum06 is expressed in cumulative ppm-hr. Several thresholds have been developed for Sum06:

Natural Ecosystems	8 - 12 ppm-hr	(foliar injury)
Tree Seedlings	10 - 16 ppm-hr	(1-2% reduction in growth)
Crops	15 - 20 ppm-hr	(10% reduction in 25-35% of crops)

W126 -- A cumulative index of exposure that uses a sigmoidal weighting function to give added significance to higher concentrations of ozone while retaining and giving less weight to mid and lower concentrations. The number of hours over 100 ppb (N100) is also considered in assessing the possible impact of the exposure. The W126 index is in cumulative ppm-hr. Several thresholds have been developed for W126:

	W126	N100
Highly Sensitive Species	5.9 ppm-hr	6
Moderately Sensitive Species	23.8 ppm-hr	51
Low Sensitivity	66.6 ppm-hr	135

In a natural ecosystem, many other factors can ameliorate or magnify the extent of ozone injury at various times and places such as soil moisture, presence of other air pollutants, insects or diseases, and other environmental stresses.

Ozone sensitive and bioindicator plant species have been identified at all ROMN units. These species were identified by cross-referencing NPSpecies with sensitive species identified in “Ozone Sensitive Plant Species on National Park Service and U.S. Fish and Wildlife Service Lands” (2003) at http://www2.nature.nps.gov/air/Pubs/BaltFinalReport1.pdf.

Sensitive species are those that typically exhibit foliar injury at or near ambient ozone concentrations in fumigation chambers and/or are species for which ozone foliar injury symptoms in the field have been documented by more than one observer. Bioindicator species for ozone injury meet all or most of the following criteria: 1) species exhibit foliar symptoms in the field at ambient ozone concentrations that can be easily recognized as ozone injury by subject matter experts, 2) species ozone sensitivity has been confirmed at realistic ozone concentrations in exposure chambers, 3) species are widely distributed regionally, and 4) species are easily identified in the field. Because of these attributes, bioindicator species are recommended for field surveys to assess ozone injury.

NPS completed a risk assessment for parks in 2004, based on the concept that foliar ozone injury on plants is the result of the interaction of the plant, ambient ozone, and the environment. That is, the risk for foliar injury is high if three factors are present: species of plants that are genetically predisposed to ozone, concentrations of ambient ozone that exceed a threshold required for injury, and environmental conditions, primarily soil moisture, that foster gas exchange and the uptake of ozone by the plant.

The assessment used ozone data from 1995-1999 to evaluate risk. All units in the ROMN were determined to be at low risk for ozone injury to vegetation. However, ozone concentrations in the region are increasing (Appendix A, figure A.4) and the assessment will need to be updated periodically as a result, taking into consideration more recent ozone values.

Visibility Monitoring
Visibility-impairing particles and gases are monitored nationwide through the IMPROVE program. Glacier NP, Great Sand Dunes NP, and Rocky Mountain NP have on-site visibility monitoring. Each has a fine particle sampler that measures the types and amounts of particles that obscure visibility. Data are available from the Visibility Information Exchange Web System (VIEWS) at http://vista.cira.colostate.edu/views/. Glacier NP and Rocky Mountain NP also have transmissometers that measure light extinction resulting from fine particles of pollution. Glacier NP has several webcams that record visibility conditions (http://www2.nature.nps.gov/air/WebCams/index.htm). Estimates of visibility conditions for the remaining ROMN units can be obtained from AirAtlas.

Visibility is degraded from natural conditions in all network units. Trend analysis indicates that visibility is improving slightly on the clearest days and worsening on the haziest days in ROMN (Appendix A, figures A.5-A.6). States are required to develop plans to make progress towards the national goal of "the prevention of any future, and the remedying of any existing, impairment of visibility in mandatory Class I federal areas which impairment results from manmade air pollution." Regional planning organizations are currently discussing these plans. The regional planning group for the western U.S. is the Western Regional Air Partnership (WRAP), with information at www.wrapair.org.

Toxic Air Pollutant Monitoring (Mercury Deposition Monitoring)
Monitoring of toxic air pollutants, including organic chemicals (e.g., pesticides, herbicides, PCBs, dioxin) and heavy metals, has been done on an ad hoc basis, but has not been done as part of a long-term nationwide network. An exception is the Mercury Deposition Network, which collects rainfall for mercury analysis at over 60 sites nationwide (http://nadp.sws.uiuc.edu/mdn/). Mercury deposition monitoring was initiated in Glacier NP in 2003. Sources of mercury include atmospheric deposition, mining activities, and natural sources. Coal contains mercury and large coal-burning power plants are major sources of mercury to the atmosphere and, eventually, terrestrial and aquatic ecosystems. Bioaccumulation of mercury in fish and wildlife has resulted in fish consumption advisories, and neurological and reproductive effects to wildlife and humans.

The NPS Western Airborne Contaminants Assessment Program (WACAP) is currently assessing the presence of airborne toxics, including certain persistent organic compounds, current-use pesticides, and mercury, in national parks in the West and Alaska, including Glacier NP and Rocky Mountain NP (http://www2.nature.nps.gov/air/studies/air_toxics/wacap.htm).

Initial Recommendations

- Continue existing air quality monitoring to provide long-term air quality information for the network.

- Initiate atmospheric deposition monitoring in Great Sand Dunes NP. Because of its recent expansion, the park now includes high elevation ecosystems that are likely to be sensitive to atmospheric deposition. Deposition monitoring would provide information on current loadings of nitrogen and sulfur compounds to these ecosystems.

- Initiate ozone monitoring at Great Sand Dunes NP. Recent trends information (Appendix A) suggests that ozone is increasing in the region.

- Update ozone risk assessments for ROMN, which were based on 1995-1999 ozone data. Increasing ozone concentrations in the region may result in higher risk categories for some parks.

- Continue ecological studies in Rocky Mountain NP to evaluate nitrogen deposition effects to sensitive ecosystems.

- Initiate mercury deposition monitoring in Rocky Mountain NP.

Relevant Websites
ARIS at http://www2.nature.nps.gov/air/
NPS AirWeb at http://www2.nature.nps.gov/air/
Air Atlas at http://www2.nature.nps.gov/air/Maps/AirAtlas/index.htm
NADP at http://nadp.sws.uiuc.edu/
MDN at http://nadp.sws.uiuc.edu/mdn/
CASTNet at http://www.epa.gov/castnet/
EPA Ozone (AirData) at http://www.epa.gov/air/data/index.html
NPS Ozone Data at http://www2.nature.nps.gov/air/data/index.htm
IMPROVE at http://vista.cira.colostate.edu/views/
Pollution sources and air quality data at http://www.epa.gov/air/data/index.html
WACAP at http://www2.nature.nps.gov/air/studies/air_toxics/wacap.htm
Nitrogen deposition: issues and Effects in Rocky Mountain NP Technical Background Document at http://www.cdphe.state.co.us/ap/rmnp/noxtech.pdf
VIEWS at http://vista.cira.colostate.edu/views/
Assessment of Air Quality and Air Pollutant Impacts in National Parks of the Rocky Mountains and Northern Great Plains at http://www2.nature.nps.gov/air/Pubs/RockyMT.Review/index.html

Appendix A: Trends in Ozone, Visibility, and Wet Deposition

1994-2003

(Source: FY 2004 Annual Performance Report: Government Performance and Results Act, Air Resources Division)

Figure A.1

Trends in SO4 Concentrations in Precipitation, 1994-2003

FY2004 Annual Performance Report for NPS Government Performance and Results Act (GPRA)

Air Quality Goal Ia3

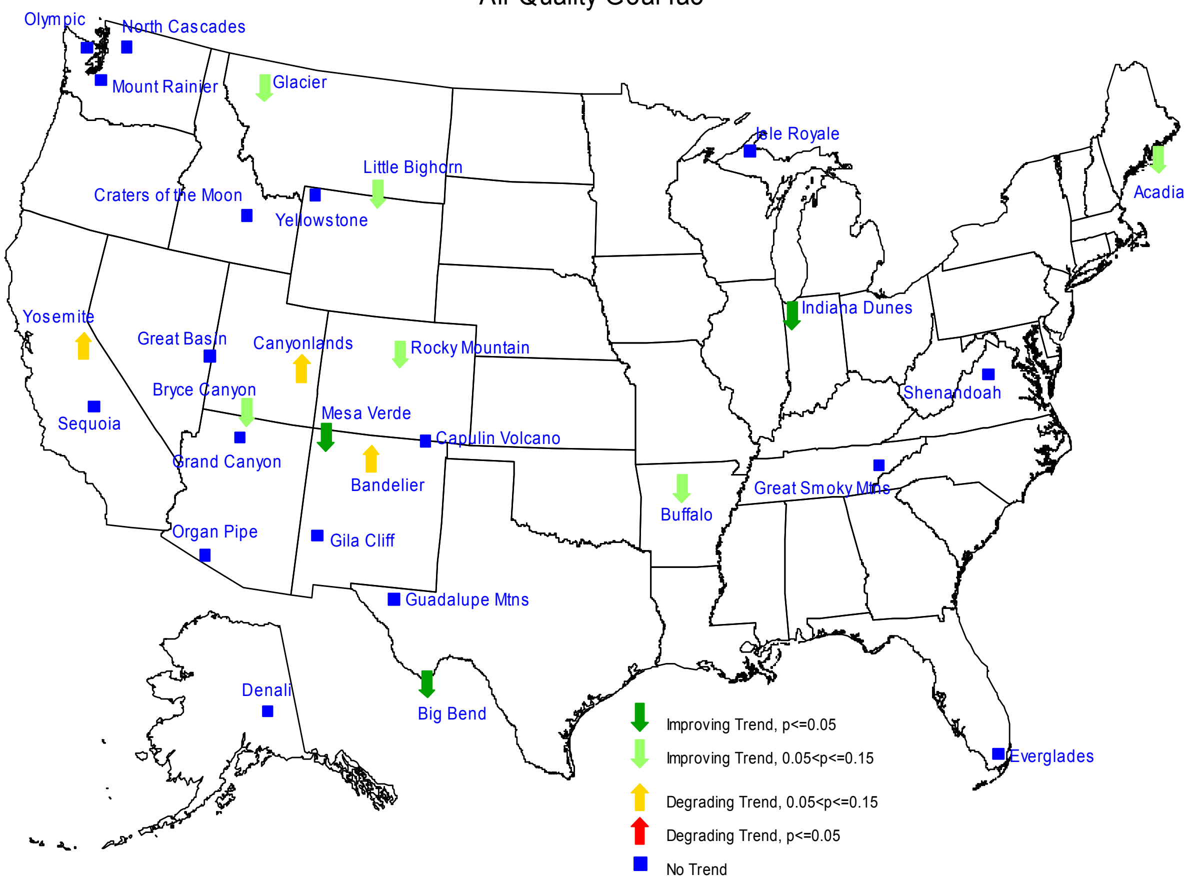


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Figure A.2

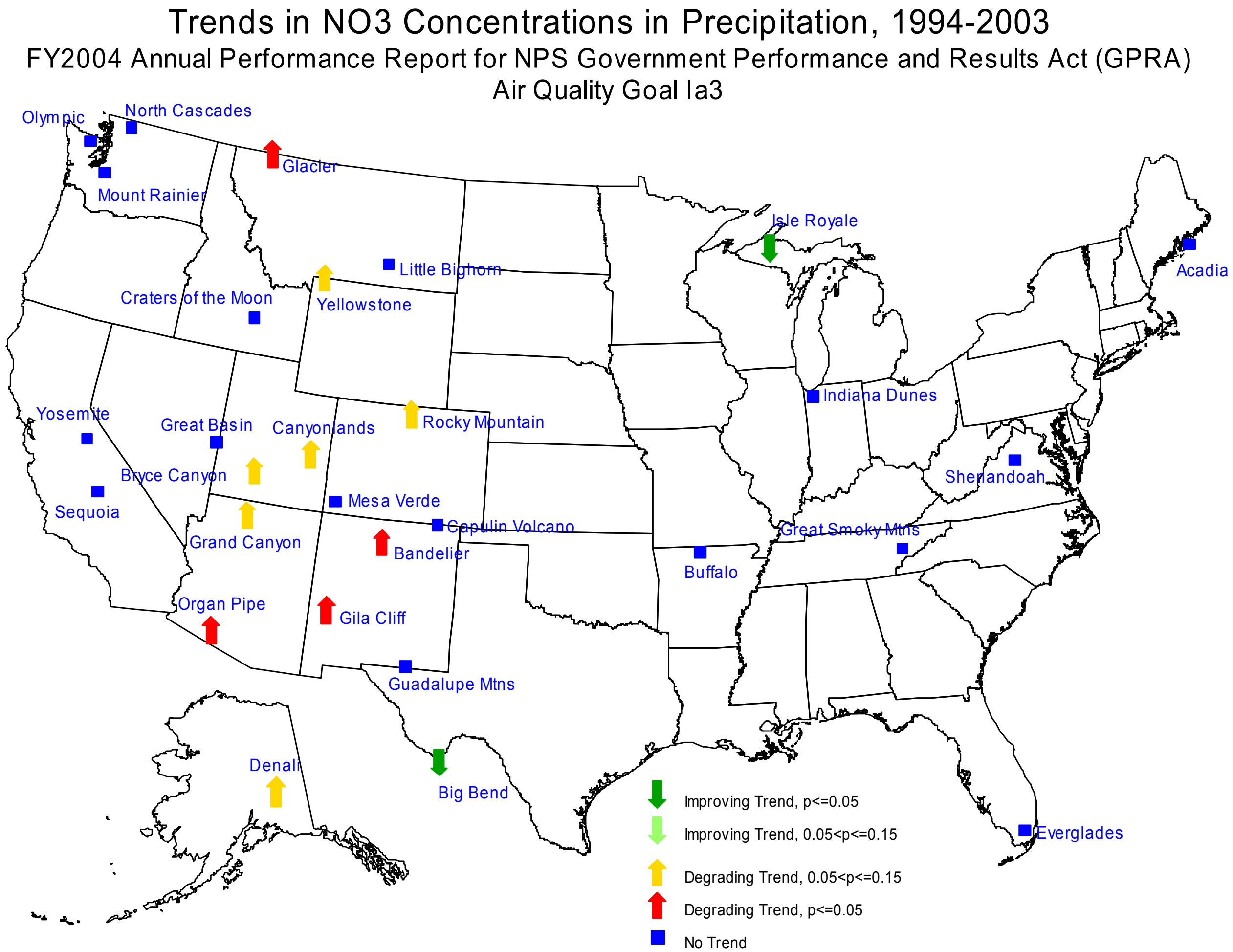

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Figure A.3

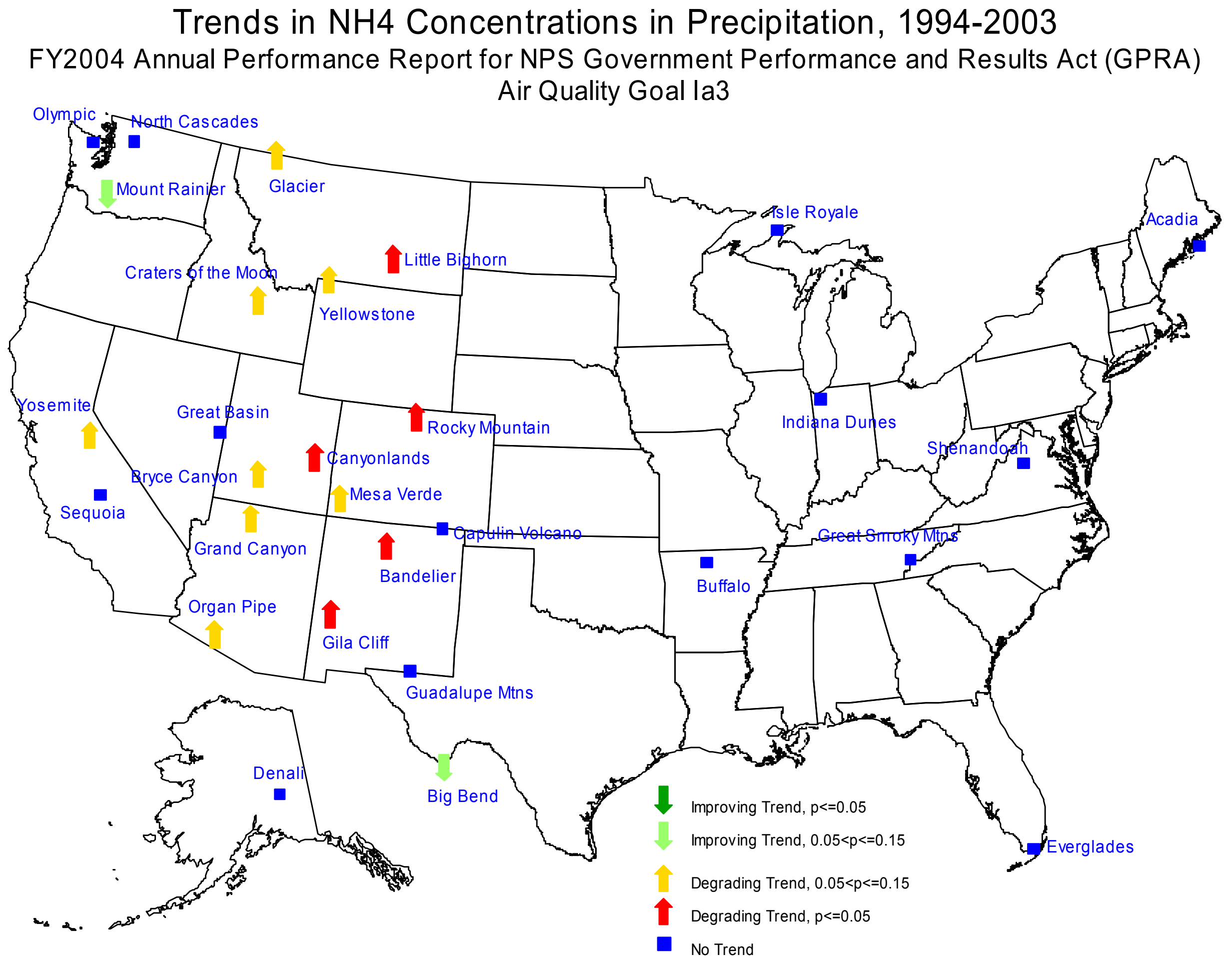

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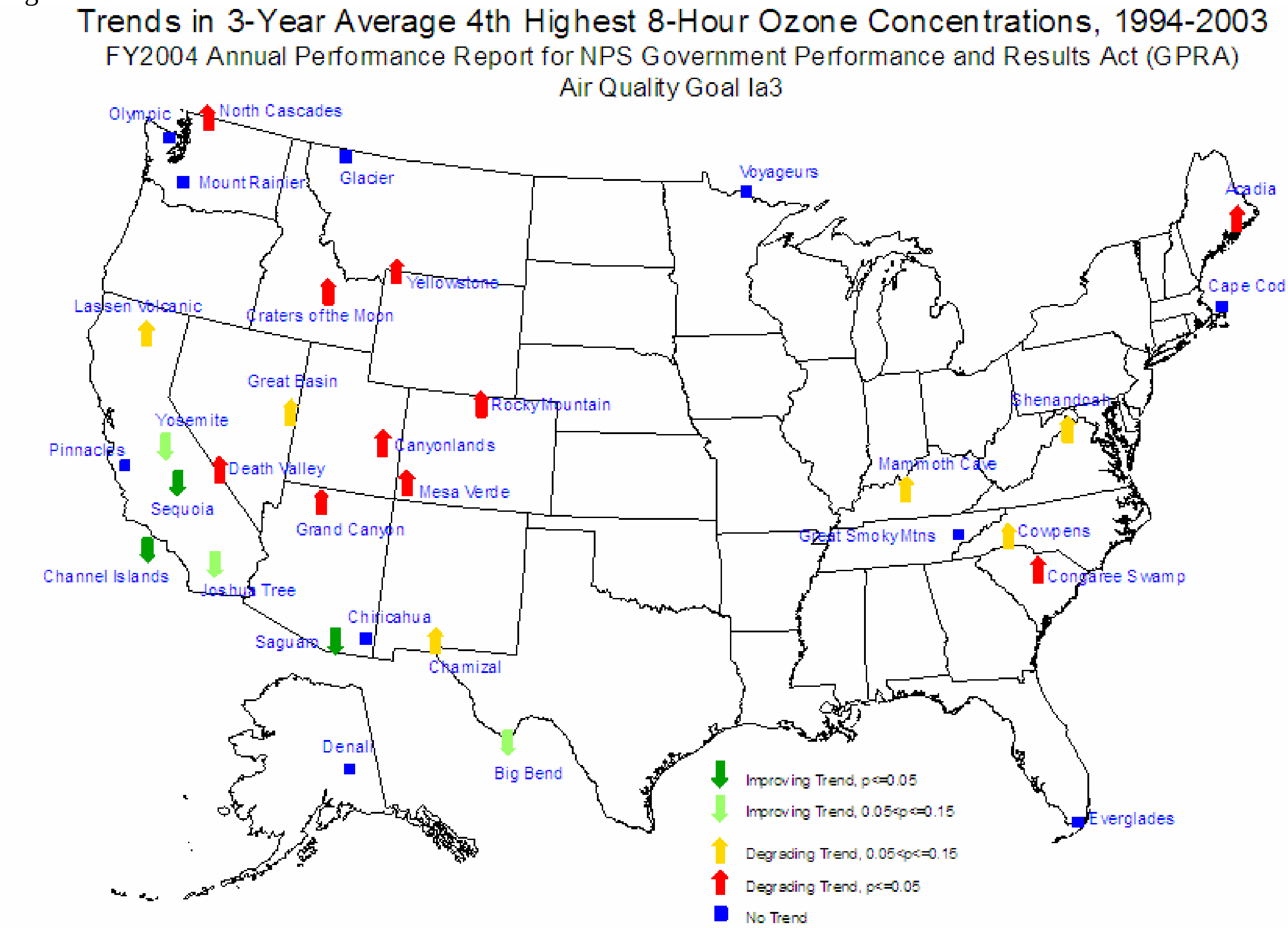
Figure A.4



Trends in 3-Year Average 4th Highest 8-Hour Ozone Concentrations, 1994-2003
FY2004 Annual Performance Report for NPS Government Performance and Results Act (GPRA)
Air Quality Goal Ia3
Olympic
North Cascades
Mount Rainier
Glacier
Voyageurs
Acadia
Yellowstone
Lassen Volcanic
Craters of the Moon
Cape Cod
Great Basin
Rocky Mountain
Yosemite
Shenandoah
Pinnacles
Canyonlands
Death Valley
Mammoth Cave
Mesa Verde
Sequoia
Grand Canyon
Great Smoky Mtns
Cowpens
Channel Islands
Joshua Tree
Congaree Swamp
Chiricahua
Saguaro
Chamizal
Denali
Big Bend
Everglades
Improving Trend, p<=0.05
Improving Trend, 0.05<p<=0.15
Degrading Trend, 0.05<p<=0.15
Degrading Trend, p<=0.05
No Trend

Figure A.5

Trends in Haze Index (Deciview) on Clearest Days, 1994-2003
FY2004 Annual Performance Report for NPS Government Performance and Results Act (GPRA)
Air Quality Goal Ia3

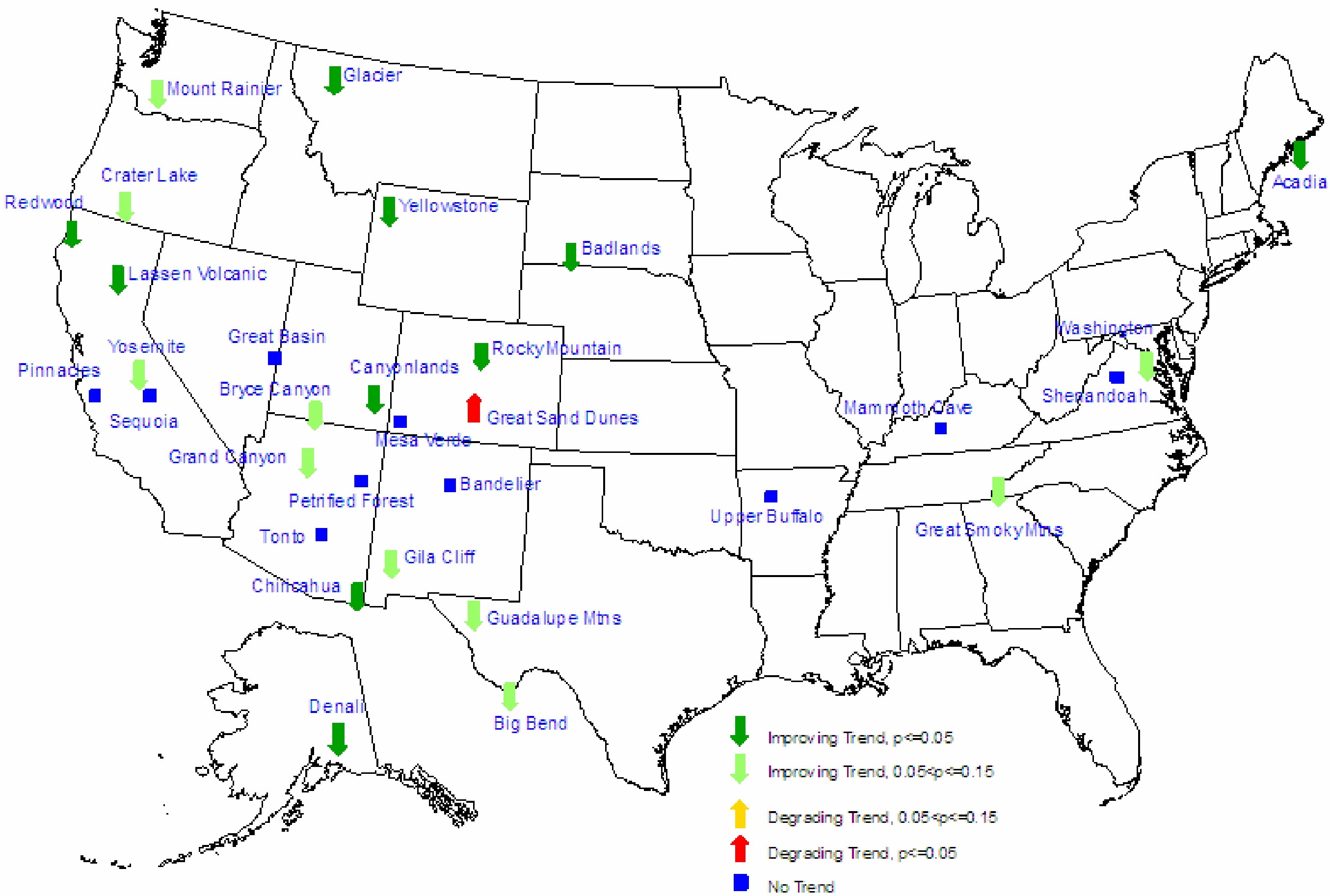
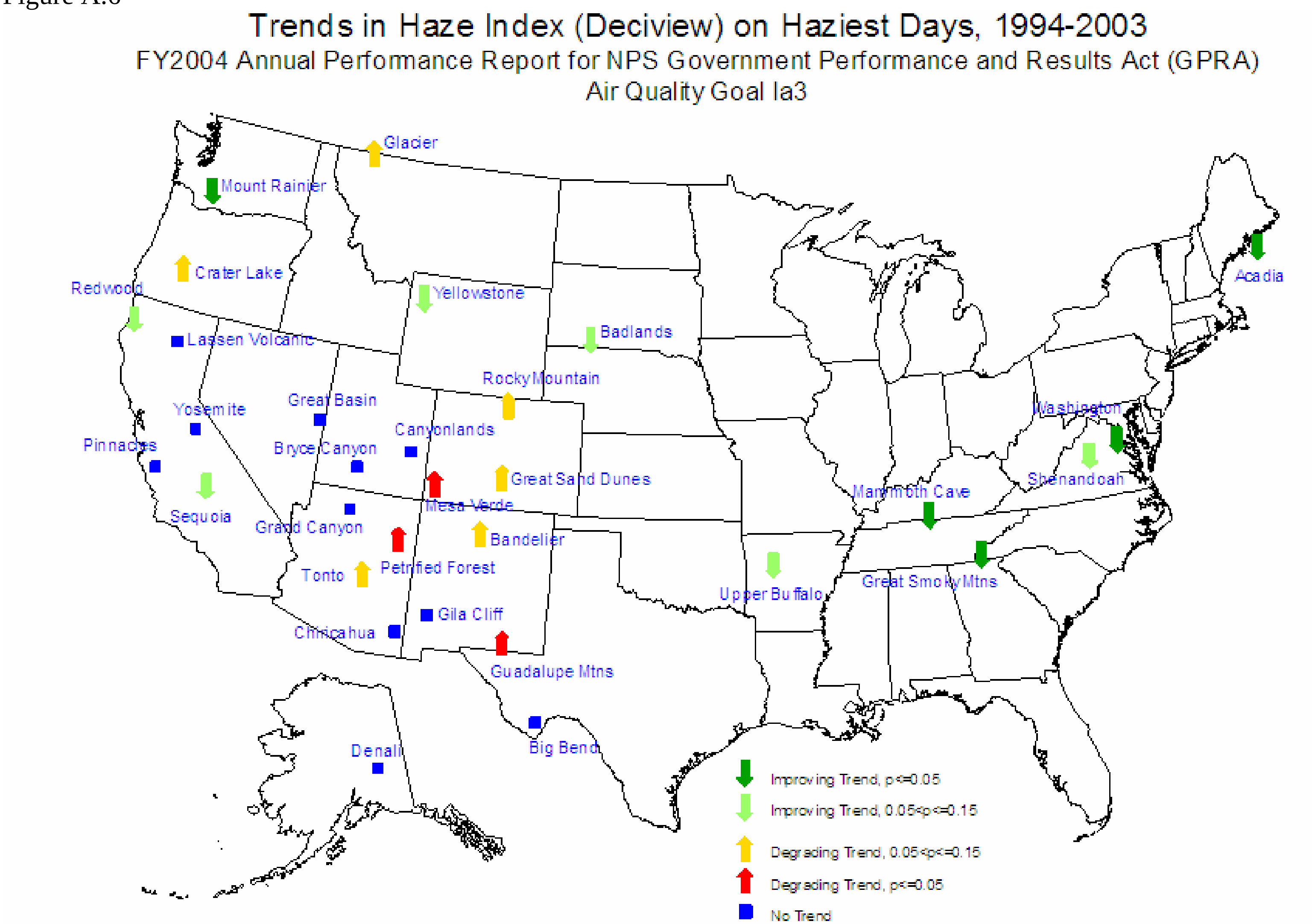


Figure A.6



Trends in Haze Index (Deciview) on Haziest Days, 1994-2003
FY2004 Annual Performance Report for NPS Government Performance and Results Act (GPRA)
Air Quality Goal Ia3
Glacier
Mount Rainier
Crater Lake
Redwood
Yellowstone
Badlands
Lassen Volcanic
Rocky Mountain
Yosemite
Great Basin
Canyonlands
Pinnacles
Bryce Canyon
Great Sand Dunes
Mesa Verde
Sequoia
Grand Canyon
Bandelier
Petrified Forest
Tonto
Gila Cliff
Chiricahua
Guadalupe Mtns
Big Bend
Denali
Acadia
Washington
Shenandoah
Mammoth Cave
Great Smoky Mtns
Upper Buffalo
Improving Trend, p<=0.05
Improving Trend, 0.05<p<=0.15
Degrading Trend, 0.05<p<=0.15
Degrading Trend, p<=0.05
No Trend